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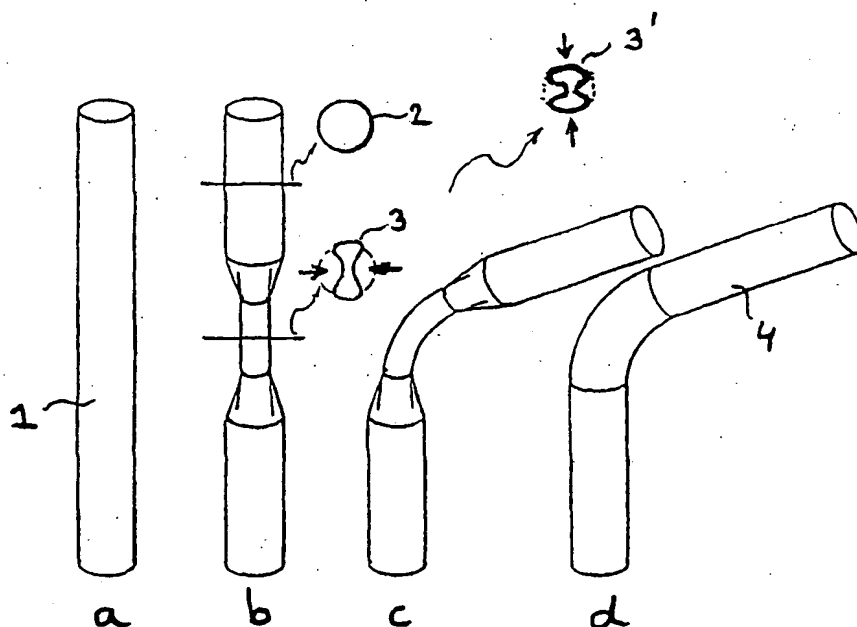
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<p>(21) International Application Number: PCT/NL00/00099 (22) International Filing Date: 17 February 2000 (17.02.00) (30) Priority Data: 1011330 17 February 1999 (17.02.99) NL (71) Applicants (for all designated States except US): CORUS STAAL BV [NL/NL]; P.O. Box 10000, NL-1970 CA IJmuiden (NL). DR. MELEGHY GMBH & CO. KG [DE/DE]; Werkzeugbau und Presswek, De-Gasperi-Strasse 8, D-51469 Bergisch Gladbach (DE). (72) Inventors; and (75) Inventors/Applicants (for US only): SCHULZE, Bernd [DE/DE]; Chernitzer Strasse 17, D-09366 Niederdorf (DE). VAN VELDHUIZEN, Hendrik, Bart [NL/NL]; Adigestraat 138, NL-1946 ZK Beverwijk (NL). (74) Agent: HERMAN DE GROOT, Johan, Willem; Corus Technology BV, P.O. Box 10000, NL-1970 CA IJmuiden (NL).</p>		<p>(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>In English translation (filed in Dutch).</i></p>

(54) Title: **PROCESS FOR DEFORMING A PIECE OF THIN-WALLED METAL TUBE**

(57) Abstract

Process for deforming a piece of thin-walled metal tube, comprising the operations of bending the piece of tube with respect to its original axis, in which process the wall of the piece of tube is firstly provided, at least at the location where the bend is intended to be, with a deformation which extends substantially in the longitudinal direction of the piece of tube, and in which process wall material is moved closer to the neutral plane of bending, and the piece of tube is then bent, after which the ultimate shape of the piece of tube which is to be deformed is imposed by hydroforming.



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PROCESS FOR DEFORMING A PIECE OF THIN-WALLED METAL TUBE

The invention relates to a process for deforming a piece of thin-walled metal tube, comprising
5 the steps of bending the piece of tube with respect to its original longitudinal axis and then hydroforming the piece of tube at least at the location where it has been bent in this way.

A known method for deforming pieces of tube
10 comprises what is known as hydroforming. In this process, the wall of the piece of tube is pressed against a mould piece under the influence of water pressure, so that the piece of tube acquires its ultimate shape. The hydroforming technique is generally
15 known and therefore does not require any further explanation here. If the piece of tube is also to be bent, a bending operation is carried out prior to and separately from the hydroforming step, in which case the bent piece of tube then acquires its ultimate,
20 desired shape through hydroforming. In this way, numerous very complicated shapes can be produced, which are used in engineering, for example in the automotive industry.

It has been found that, in this processing
25 method, the bending of the piece of tube forms a critical step. Particularly if a small wall thickness is used for the piece of tube, cracks are rapidly formed along the outside of the bend during the bending operation, while wrinkles are formed in the compressed
30 region along the inside of the bend. These wrinkles in this case occur in the circumferential direction of the piece of tube, i.e. they run in a direction which is transverse with respect to the longitudinal axis of the piece of tube. If the bent piece of tube is then
35 subjected to a hydroforming operation, it is found that wrinkles of this nature running in the circumferential direction can no longer be removed. The result is an unacceptable product.

Therefore, the object of the invention is to provide a method in which the production of bent, thin-walled pieces of tube and of products formed using such pieces of tube causes fewer problems. In particular, it is intended to reduce the risk of cracking and to avoid the formation of wrinkles in the circumferential direction.

In the process described in the preamble, this is achieved if the piece of tube, before it is bent, is indented on both the inside and the outside of the bend which is to be formed at the location where it will exhibit a bend as a result of the bending operation.

As a result of the indentation, which involves moving wall material closer to the neutral plane of bending stresses, the piece of tube can be bent more easily, with the result that the risk of cracking and the formation of wrinkles in the circumferential direction is reduced considerably. The ultimate shape of the piece of tube which is to be deformed can then be imposed during the subsequent hydroforming operation, during which any deformations which may have been imposed in the longitudinal direction can be eliminated, or further deformations can be produced. It should be noted that, surprisingly, it has been found that wrinkles in the wall of the bent piece of tube which run in the longitudinal direction, i.e. more or less parallel to the axis of the piece of tube, are no longer visible after the hydroforming has taken place.

The process can be used in order to impart a constant cross section to the deformed piece of tube along its length, in that the undeformed piece of tube is firstly provided with longitudinal wrinkles on either side of the neutral plane as a result of compression, and then, after the bending operation, the constant cross section is restored by the hydroforming step. It has been found that in this way pieces of thin-walled tube with a constant cross section and a relatively small radius of curvature can be produced

successfully. In the past, the production of pieces of tube of this nature caused considerable problems.

In one embodiment of the process according to the invention, the piece of tube, after the indenting
5 step and before and/or after the bending step, is deformed in such a manner that at least part of the material which forms the piece of tube, which part, as seen in cross section through the piece of tube, is situated in a region between regions where the piece of
10 tube is indented, is moved closer to the centre of gravity of the cross section. This further reduces the risk of cracking and/or wrinkling.

The invention will now be explained with reference to a number of figures.

15 Figs. 1 a-d show the production of a bend piece of constant cross section from a straight piece of tube.

Fig. 2 shows the production of a tubular product of complicated shape from a straight piece of
20 tube.

In Fig. 1, a, b, c and d illustrate various phases of the production of the bend piece 4. In Fig. 1a, reference numeral 1 denotes a straight piece of tube which is to be formed into the bend piece 4
25 shown in Fig. 1d.

Fig. 1b shows the piece of tube 1 with cross section 2 after the wall has been compressed from either side half-way along the piece of tube, with the result that wall wrinkles are formed in the
30 longitudinal direction. The cross section of the piece of tube at the location of these longitudinal wrinkles is indicated by 3. The arrows which are directed towards one another diagrammatically indicate the indentation according to the invention. Arrows directed
35 towards one another at 3' indicate any further deformation of the piece of tube before or after bending. Fig. 1c shows how the piece of tube can easily be bent at the location of the thinned middle piece, partly as a result of the considerable reduction in the

section modulus of the cross section at that location. The risk of cracks or wrinkles in the circumferential direction occurring is considerably reduced as a result. The shape shown in Fig. 1d can be obtained by
5 subjecting the product shown in Fig. 1c to a hydroforming operation.

Fig. 2 illustrates the production of a workpiece with a more complicated shape. In Figs. 2a1 and a2, a front view of and a cross section through a
10 piece of tube are illustrated. Figs. 2d1 and d2 show a side view of and a cross section through the product 9 formed therefrom. At location 7, longitudinal wrinkles are pressed into the piece of tube 5, with the result that a cross section of the shape of 8 is formed at
15 that location (cf. Figs. 2b1 and b2). The shape shown in Figs. 2c1 and c2 is obtained through bending of the piece of tube.

From this, the final shape 9 can be obtained by hydroforming; numerous variations on this shape are
20 conceivable.

CLAIMS

1. Process for deforming a piece of thin-walled metal tube, comprising the steps of bending the piece
5 of tube with respect to its original longitudinal axis and then hydroforming the piece of tube at least at the location where it has been bent in this way, in which process the piece of tube, before it is bent, is indented on both the inside and the outside of the bend
10 which is to be formed at the location where it will exhibit a bend as a result of the bending operation.

2. Process according to Claim 1, in which the indenting comprises the step of pressing in wrinkles which run substantially parallel to the longitudinal
15 axis.

3. Process according to Claim 1 or 2, in which the piece of tube, after the indenting step and before and/or after the bending step, is deformed in such a manner that at least part of the material which forms
20 the piece of tube, which part, as seen in cross section through the piece of tube, is situated in a region between regions where the piece of tube is indented, is moved closer to the centre of gravity of the cross section.

Fig. 1

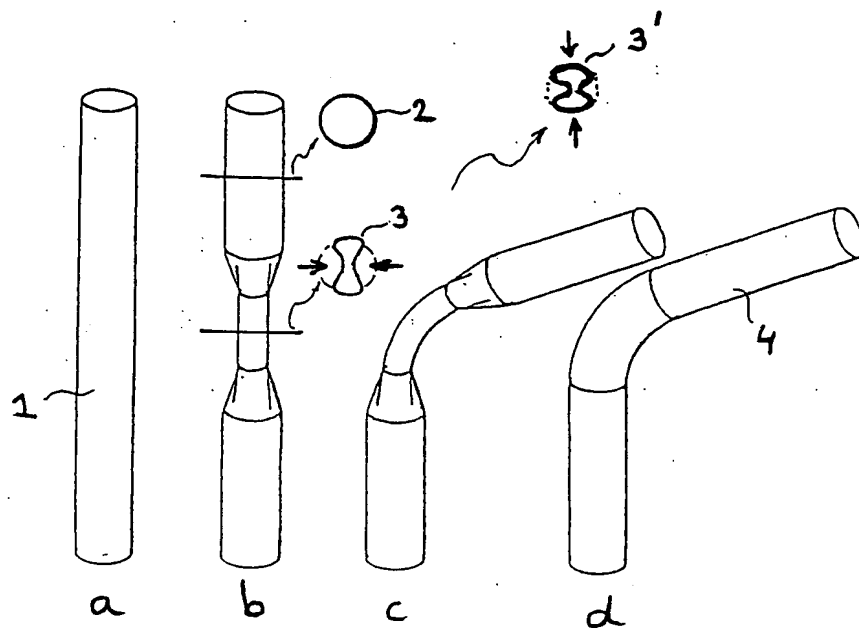
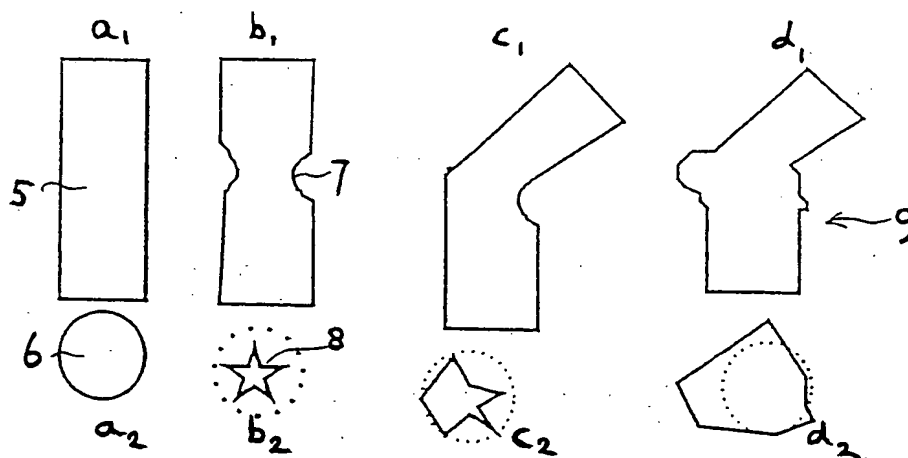


Fig. 2



INTERNATIONAL SEARCH REPORT

Inte. onal Application No

PCT/NL 00/00099

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B21D26/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 010, no. 261 (M-514), 5 September 1986 (1986-09-05) & JP 61 086029 A (NISSAN MOTOR CO LTD), 1 May 1986 (1986-05-01) abstract	1-3
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A	DE 44 28 564 A (DAIMLER BENZ AG) 22 June 1995 (1995-06-22) -/-	

☒ Further documents are listed in the continuation of box C.

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INTERNATIONAL SEARCH REPORT

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A	EP 0 770 435 A (BENTELER WERKE AG) 2 May 1997 (1997-05-02) ---	
A	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 11, 29 November 1996 (1996-11-29) & JP 08 192238 A (TUBE FORMING:KK), 30 July 1996 (1996-07-30) abstract -----	

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Information on patent family members

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